STATISTICAL STUDIES ON THE ELECTRIFICATION OF MINOR SHOWERCLOUDS

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Special Contributions, Geophysical Institute, Kyoto University, No. 6, 1966, 1–7

STATISTICAL STUDIES ON THE ELECTRIFICATION OF MINOR SHOWERCLOUDS

By

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(Received November 18, 1966)

Abstract

During the cold seasons from November 1955 to March 1960, many cases of electric field caused by minor showercloud were observed in Kyoto. Using these data, the types of electric field and the intensities of electric field were statistically studied. It was found the polarity of minor showercloud is negative, that is, negative charge upper and positive charge lower.

1. Introduction

In the cold season, from the end of October to the end of March, after the passage of a continental cyclone, small showers having a little precipitation (rain, snow or graupel) appear in the major part of Japan. According to our experiences in Kyoto, the appearance of such showers is very characteristic, that is, precipitation begins quite unexpectedly and short precipitaion is immediately followed by a blue sky ; and not infrequently, such alternation is repeated several times in succession. Such phenomena are defined as minor shower. Generally, the dimension of such minor shower is the order of 2∼3 km and electrical disturbance on the ground is very intense, frequently exceeds 2000 V/M both positive and negative sign. Typical example of electric field caused by a minor showercloud is reproduced in Fig. 1. It was expected that an investigation of electrification of minor showerclouds would be very interesting, especially in connection with thunderstorm electricity, and that it would be made without great difficulty, owing to large electrical display in spite of their small scale and to their frequent appearance.

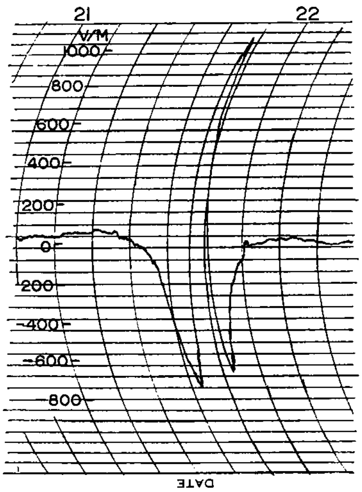

Fig. 1. Example of electric field caused by a minor showercloud. (observed at Shugakuin, 21^h00–22^h30, November 1955)

During the cold seasons from November 1955 to March 1960, a systematic investigation of the electrification of minor showerclouds had been made by network observation of surface electric field in the area of northern part of Kyoto City. A network consisted of ten stations was used from early winter 1955 to early spring 1956, and from early winter 1958 to early spring 1959; in the other seasons three stations worked. For the measurement of electric field, a field meter of generating voltmeter type was used during the whole seasons except the last two, in which a polonium collector device was used instead of the field meter (Tamura [1956], [1961]). By the network observations at ten stations, the polarity of minor showerclouds was found as negative, that is, negative charge upper and positive charge lower (Tamura [1956], [1961]). In the present report, however, some results of statistical studies on the electrification of minor showerclouds were discussed. For this purpose, results of observation at one or two selected stations were used.

2. Statistical study on the types of electric field of minor showercloud

Since the study of clectrification of minor showercloud began at November of 1955, a large number of the electric field records of the cloud have been obtained. In some cases the cloud was isolated and its electric field showed a characteristic type, in the other cases more than one cloud appeared in succession or simultaneously, accordingly the electric fields were observed as a superposition of individual ones. In the case of a single cloud its characteristic feature

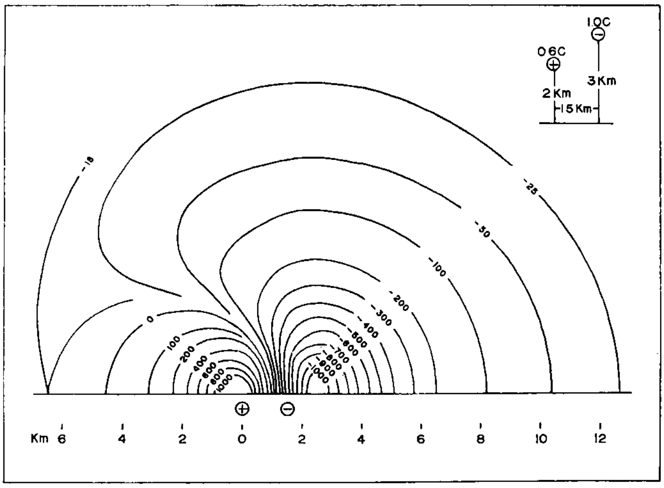

Fig. 2. Electric field pattern on the plane ground caused by a bipolar charge distribution; -1 and $+0.6$ coulomb at a height of 3 and 2 km respectively and horizontal separation of 1.5 km. Field intensity is shown in volt per meter.

of record is classifiable to a certain definite type. As the number of the cases was very large, it is expected that the statistical study with respect to the types shall give useful informations about the polarity of the cloud. Fig. 2 is a model pattern of the electric field due to a bipolar charge distribution of negative polarity in a cloud which tentatively assumed as the minor showercloud. When the pattern is unchanged with the time and proceeds with uniform velocity, an observing station will experience a certain cross section of the pattern, that is, the spatial field distribution along a line can be shown as a time change of the field. When a large number of clouds pass by, various cross sections of the field pattern will be experienced at one station. In the actual case there may be varieties of charge distribution in a cloud, however, if the number of observation is large, types of field change at one station will give valuable informations about the electric field of the cloud. Fig. 3 shows various profiles of the field pattern in Fig. 2, which cover all the possible types disregarding the quantitative difference. The profile N is a representative of the profiles having a maximum in the positive side and a minimum in the negative side. Apparent inverted profile N belongs to the profile N. And also, the profile Z is a representative of the profiles having two minima of different value in the negative side and a maximum in the positive side between the minima. When the field pattern is fixed on the ground and the observations are made with uniform velocity across the pattern, the similar profiles are also obtained by the timely change of the field. Further, if the polarity of the bipole is opposite, the profiles showing opposite sign of electric field are obtained. It is remarked that in both cases —negative polarity and positive polarity— some profiles have no essential difference, but some have essential difference between negative and positive polarities, that is, the profile N is obtained in both cases of polarity, and there is no remarkable difference between V and inverted P, or between P and inverted V, but Q, Z and W will clearly be distinguishable from the corresponding inverted types. Thus, some types of the field change cannot give informations about the polarity of the cloud, but some are used as the discriminant for the sign of the polarity.

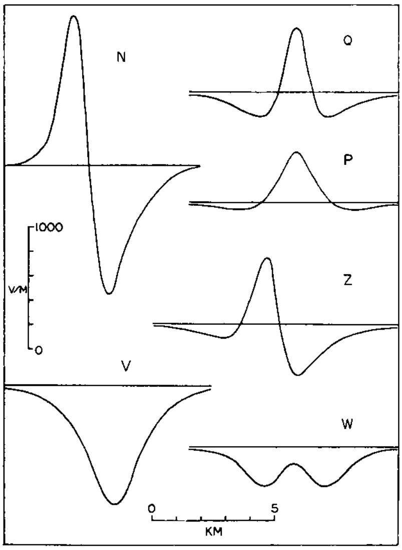

Fig. 3. Various profiles of bipolar electric field pattern.

The statistical data showing the occurrence frequencies of the various types

Table 1. Occurrence frequency of types of electric field profile (Observed at Geophysical Institute, Kyoto University)

Month	Type	N	V	Q	P	Z	W	Complex	Inverted Q Inverted Z	Sum	
1955	Nov.	1	0	0	0	1	2	1	0	5	
	Dec.	8	9	2	4	5	6	6	3	43	
1956	Jan.	16	7	1	0	5	5	6	0	40	195
	Feb.	24	7	6	5	5	3	14	5	69	
	Mar.	6	6	15	0	0	3	7	1	38	
	Sum	55	29	24	9	16	19	34	9		
	Nov.	11	11	6	0	0	6	9	1	44	
	Dec.	0	8	2	2	0	0	0	1	13	
1957	Jan.	11	11	5	5	0	9	10	7	58	238
	Feb.	6	12	4	5	4	10	6	0	47	
	Mar.	11	9	0	8	5	9	21	13	76	
	Sum	39	51	17	20	9	34	46	22		
	Nov.	6	5	0	0	1	8	5	3	28	
	Dec.	6	12	0	1	3	4	6	0	32	
1958	Jan.	17	13	2	2	8	12	8	7	69	211
	Feb.	8	2	0	3	5	2	3	4	27	
	Mar.	12	9	1	1	9	12	4	7	55	
	Sum	49	41	3	7	26	38	26	21		
	Nov.	4	3	0	4	3	0	7	1	22	
	Dec.	29	29	4	14	7	10	17	2	112	
1959	Jan.	13	16	6	12	16	11	2	2	78	424
	Feb.	15	26	4	14	21	27	5	1	113	
	Mar.	25	21	3	17	7	18	3	5	99	
	Sum	86	95	17	61	54	66	34	11		
	Nov.	2	3	3	1	1	3	1	1	15	
	Dec.	8	0	3	2	2	2	2	0	19	
1960	Jan.	7	7	2	8	3	2	2	0	31	127
	Feb.	8	2	1	5	2	4	4	0	26	
	Mar.	6	7	1	6	4	6	2	4	36	
	Sum	31	19	10	22	12	17	11	5		
	Total	260	235	71	119	117	174	151	68		1195

of field change disregarding —the scales-the magnitude and the duration of field change— correspond to the profiles given in Fig. 3, are shown in Table 1. These data were obtained in the cold seasons during the period from 1955 to 1960 at the Geophysical Institute. In the table, the "complex" means a type hardly classifiable to a definite type. The sum of N, V and P is 614, the sum of Q, Z and W is 362 and the numbers of inverted Q and inverted Z are 68, and each is 51%, 30% and 6% of the total number of 1195. Thus, 51% of 1195 cases of the clouds were of bipolar character, but equally were favorable to the positive and negative polarities. 30% of the cases were favorable to the negative polarity, while 6% of the cases were favorable to the positive polarity and the remaining 13% were complex type seemed to be due to a cloud of non-bipolar character. If it is allowed to divide the uncertain 51% cases into two parts by the ratio 30 : 6 as favorable cases to the negative and the positive polarities respectively, then 74% of the total cases of field profile are favorable to the negative polarity, while 13% are favorable to the positive polarity.

3. Statistical study on the intensities of electric field caused by minor showercloud

It is of interest to know the change of minor showercloud electrification with lapse of time. To this end, the relations between a duration and a cloud electric field whose intensity within the duration exceeded a specified value were statistically obtained at two stations A (Geophysical Institute) and F (Iwakura). The latter station was at the distance of about 4 km, north from the former. The used data were those of concurrent minor showerclouds at the two stations. The concurrent data available for this purpose were somewhat limited, that is, about 90 clouds. For convenience' sake, electric field intensities exceeding 200 V/M from the zero level both positive and negative signs were taken as the cloud electric field; the electric field weaker than this level was considered to be unreliable for the present purpose. For the station A, the field within ±1400 V/M and for the station F, the field within ±2600 V/M were available. The results are shown in Fig. 4 (the data exceeding ±2000 V/M at F station are not cited). It is seen that the relations between the duration and the field intensity have similar trend to the positive and the negative fields and also to the case of the stations A and F. But, for a specified duration the corresponding field

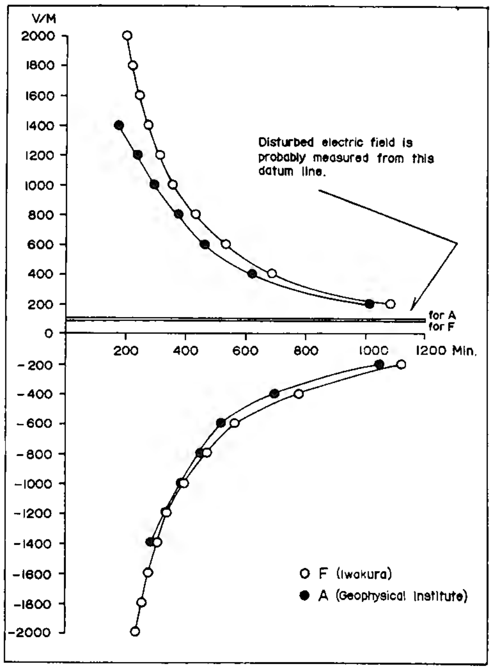

Fig. 4. Statistical data showing duration of disturbance versus intensity of electric field, caused by about 90 minor showerclouds during the period February—March 1959.

intensities both positive and negative signs are greater at F station than at A station. Since, generally, the minor showercloud proceed from north or northwest to south or southeast, the fact mentioned above suggests that the electrification of minor showercloud weakens as the cloud travels. It must also be remarked that, for the positive field, the curve at the station A deviates from the curve at the station F to smaller side of the duration as the field becomes larger; while, for the negative field, the curve at A closes to that at F to larger side of the duration at the field becomes larger. These facts indicate that the dissipation of positive charge in the clouds is larger than that of negative charge in the course of travel of cloud. It is possible that positive charge in the lower part of cloud will be more effectively dissipated than negative charge in the upper part of cloud, by a discharging current between cloud base and the ground. In Fig. 3, the field intensities are measured from the zero level, but the electric field which is due to minor showerclouds is probably measured from the normal fine weather field as the datum line, which is +100 V/M and +80 V/M for A and F stations respectively. These values are the average of the daily course of potential gradient on the calm days in the cold season, at the respective stations (Okawati [1961]). The curves in Fig. 5 were obtained from the observation in the cold season, 1955-56 at Geophysical Institute.

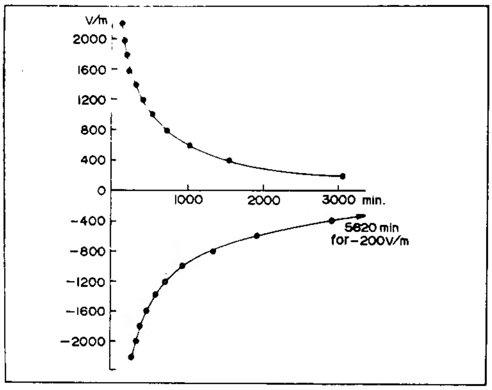

Fig. 5. Statistical data showing duration of disturbance versus intensity of electric field, caused by about 200 minor showerclouds during the period October 1955—March 1956. (from the observation at Geophysical Institute)

From the statistical studies described here, it may be fairly confirmed that the polarity of minor showerclouds is negative, that is the upper part of cloud has negative charge and the lower part has positive charge.

Acknowledgements

The research was made possible by financial aid received from Geophysics Research Directorate, Air Force Cambridge Research Center under the Contracts AF 62(531)-223 and AF 62(531)-909.

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